



**US Army Corps
of Engineers**

Waterways Experiment
Station

**Preliminary Data Summary
July 1999
Field Research Facility**

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1 Introduction

The U.S. Army Corps of Engineers Waterways Experiment Station, Coastal and Hydraulics Laboratory (CHL), Field Research Facility (FRF) is located on the Outer Banks of North Carolina, near the village of Duck (Figure 1).

The FRF research program provides a means for obtaining high-quality field data, particularly during storms, in support of the U.S. Army Corps of Engineers' coastal engineering research missions. Central to the FRF is the research pier, a reinforced concrete structure which extends from behind the duneline to about the 6-m water depth contour at a height of 7.75 m above the NGVD (1929 National Geodetic Vertical Datum).

One of the responsibilities of the FRF research program is the collection, analysis and dissemination of data on local bathymetric, oceanographic, and meteorological conditions. This is a preliminary which provides basic data soon after collection. Since they are preliminary further quality control may be applied to the data and made available via the internet at <http://www.frf.usace.army.mil>. Questions and/or comments concerning the data may be directed to Mr. Clifford F. Baron at (919)261-6840 ext.222 (baronc@wes.army.mil).

Chapter 2 presents the meteorological data; Chapters 3 through 6 present oceanographic data; Chapter 7 presents nearshore profiles and bathymetry; and Chapter 8 documents special events that occurred at the FRF during the month.

Table 1 is a list of instruments used and their operational status during the month. Figure 2 shows weather and ocean conditions for the month. Table 2 and Figure 3 identifies the location of the instruments. The water depths at the wave gauges and current meters vary and may be determined from information contained in Figure 9. Other installation information is contained in Table 2.



Figure1. FRF Location Map

Times given in the report are referenced to eastern standard time (EST).

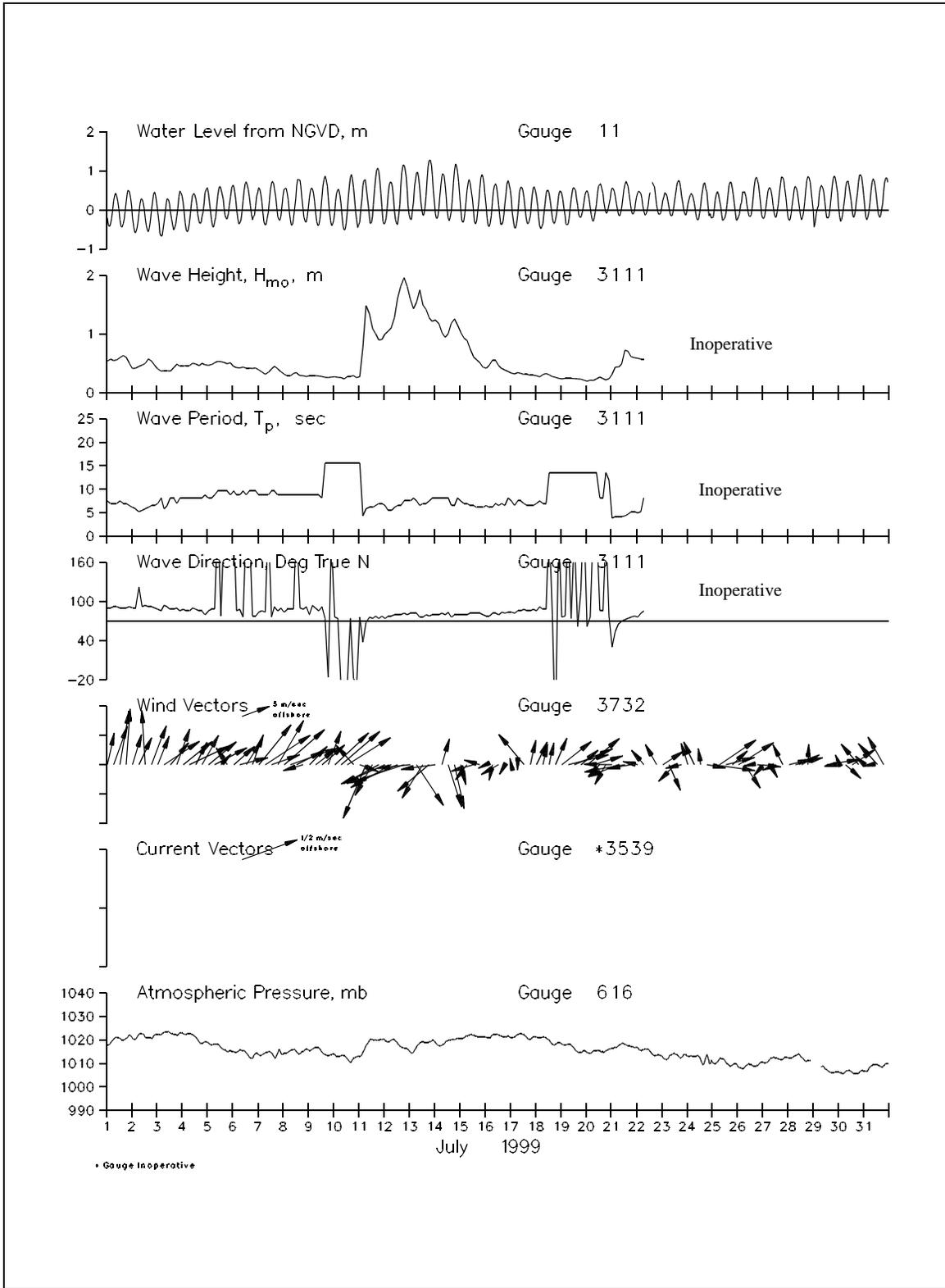


Figure 2. Month at a Glance

**Table 1
Instrument Status/Data Availability**

		July 1999		Day of the month																																	
Gauge ID	Description/Remarks			1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	6	7	8	9	0	1	2	2	2	2	2	2	2	2	2	3	3		
616	Atmospheric Pressure	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
604	Precipitation	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
624	Air Temperature	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3732	Anemometer	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
641	Pressure Gauge on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
625	Baylor staff on FRF pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3111	8 Meter Array 309 m north of FRF	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
111	Pressure Gauge center of 8 Meter Array	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
630	Waverider buoy 4.0 km offshore	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
3539	Current meter 343 m north of FRF pier (1.6 km offshore)	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	Data available at a later date.																																		
11	NOAA tide gauge at end of pier	Gauge Status	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	
		Data Collected	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
	Visual Observations (daily oceanographic and meteorological observations)	Daily observation	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	

Gauge Status * = Operational / = Partial - = Non-Operational
 Data Collected * = All / = Partial - = None
 Visual Observations * = Complete / = Partial - = None

Table 2 Gauge Locations

Gauge ID	Description	Latitude Degrees N	Longitude Degrees W	FRF Coordinates		Gauge Depth NGVD, m	Water Depth NGVD, m
				Crossshore m	Longshore m		
616	Atmospheric Pressure	36 10' 57.03"	75 45' 5.50"	11.60	569.00	-----	-----
3932	Anemometer	36 11' 1.23"	75 44' 43.07"	585.20	517.30	19.50	-----
641	Pressure Gauge	36 10' 57.71"	75 44' 56.23"	239.11	516.64	-1.64	-1.96
625	Baylor Staff	36 11' 1.04"	75 44' 43.72"	568.00	516.64	Surface	-8.36
3111	8 Meter Array North	36 11' 19.14"	75 44' 36.41"	915.23	990.16	-7.50	-7.90
	8 Meter Array South	36 11' 11.28"	75 44' 33.28"	914.20	735.37	-7.42	-7.90
	8 Meter Array East	36 11' 13.70"	75 44' 32.56"	954.51	800.58	-7.62	-8.13
	8 Meter Array West	36 11' 12.48"	75 44' 37.11"	834.66	800.37	-6.98	-7.44
111	Pressure Gauge in center of 8 M Array	36 11' 14.06"	75 44' 34.39"	914.43	825.52	-7.76	-8.08
630	Waverider Buoy	36 10' 5.10"	75 41' 59.30"	3934.96	-2400.81	Surface	-17.00
3539	Current Meter	36 11' 23.57"	75 44' 9.12"	1605.80	907.60	-11.60	-11.70
11	NOAA Tide Gauge	36 11' 1.25"	75 44' 42.60"	596.49	514.20	Surface	-7.62

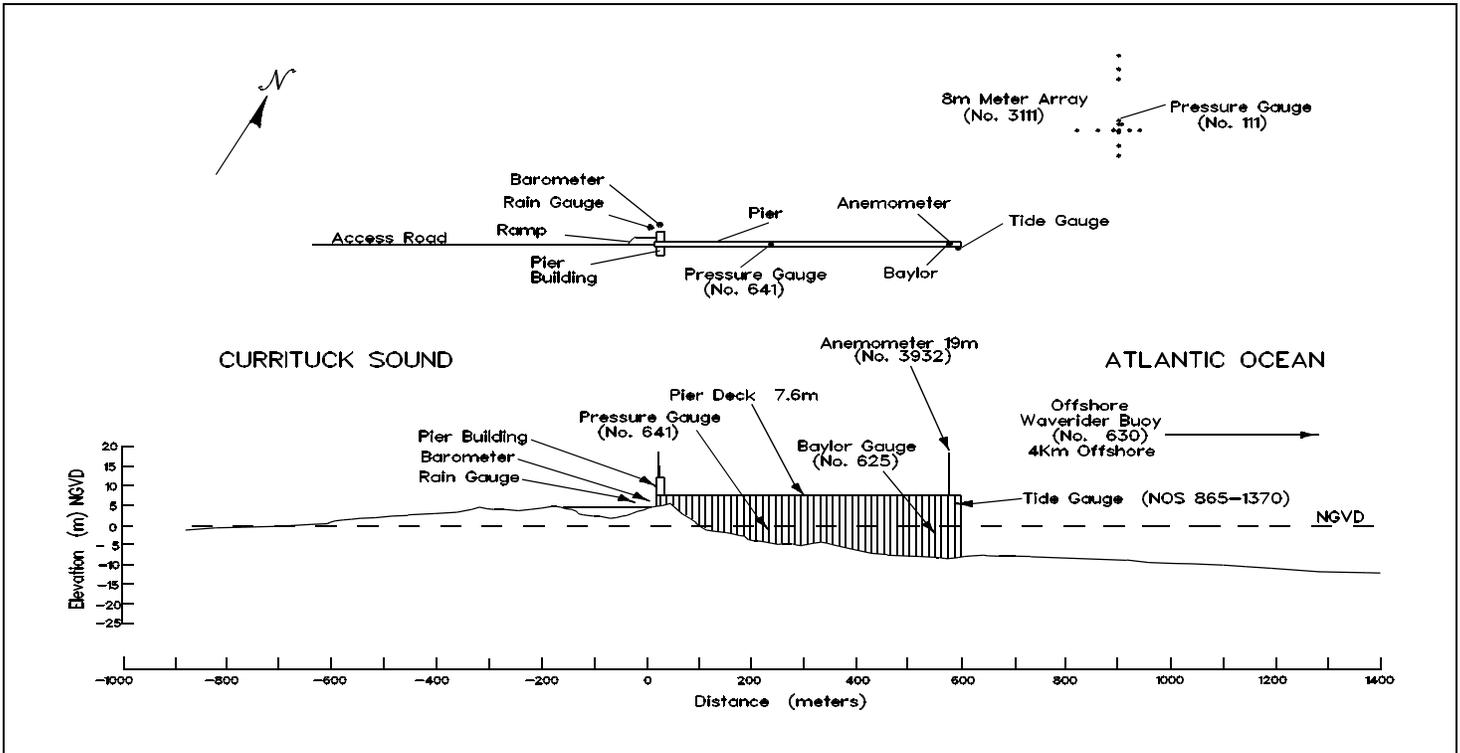


Figure 3. Instrument Locations, Elevations From NGVD

2 Meteorological Data

A variety of instruments have been installed at the FRF (Figure 3) to monitor the meteorological conditions. The data presented in Table 3 are collected and stored using a Digital Equipment Corporation VAXstation 4000. For each instrument identified in Table 1, a log is maintained and the records are stored for future reference.

Winds were measured at the end of the pier at an elevation of 19 m using a WeatherMeasure Skyvane anemometer. Monthly resultant wind speeds and directions (Figure 4) are determined by vector averaging the data. Wind directions (Table 3) indicate where the wind is coming from. Temperature and atmospheric pressure means (Table 3) are the average of the values presented for the month. Total precipitation is the sum for the month.

The following may be useful for converting the data in Table 3 to other frequently used units of measurement:

1. Millimeters (mm) to inches (in.) -
 $\text{mm} \times .03937 = \text{in.}$
2. Millibars (mb) to inches of mercury (in. Hg) -
 $\text{mb} \times 0.02953 = \text{in. Hg}$
3. Degrees Celsius (C) to degrees Fahrenheit (F) -
 $(\text{C} \times 9/5) + 32 = \text{F}$
4. Meters per second (m/s) to knots (kn) -
 $\text{m/s} \times 1.943 = \text{kn}$

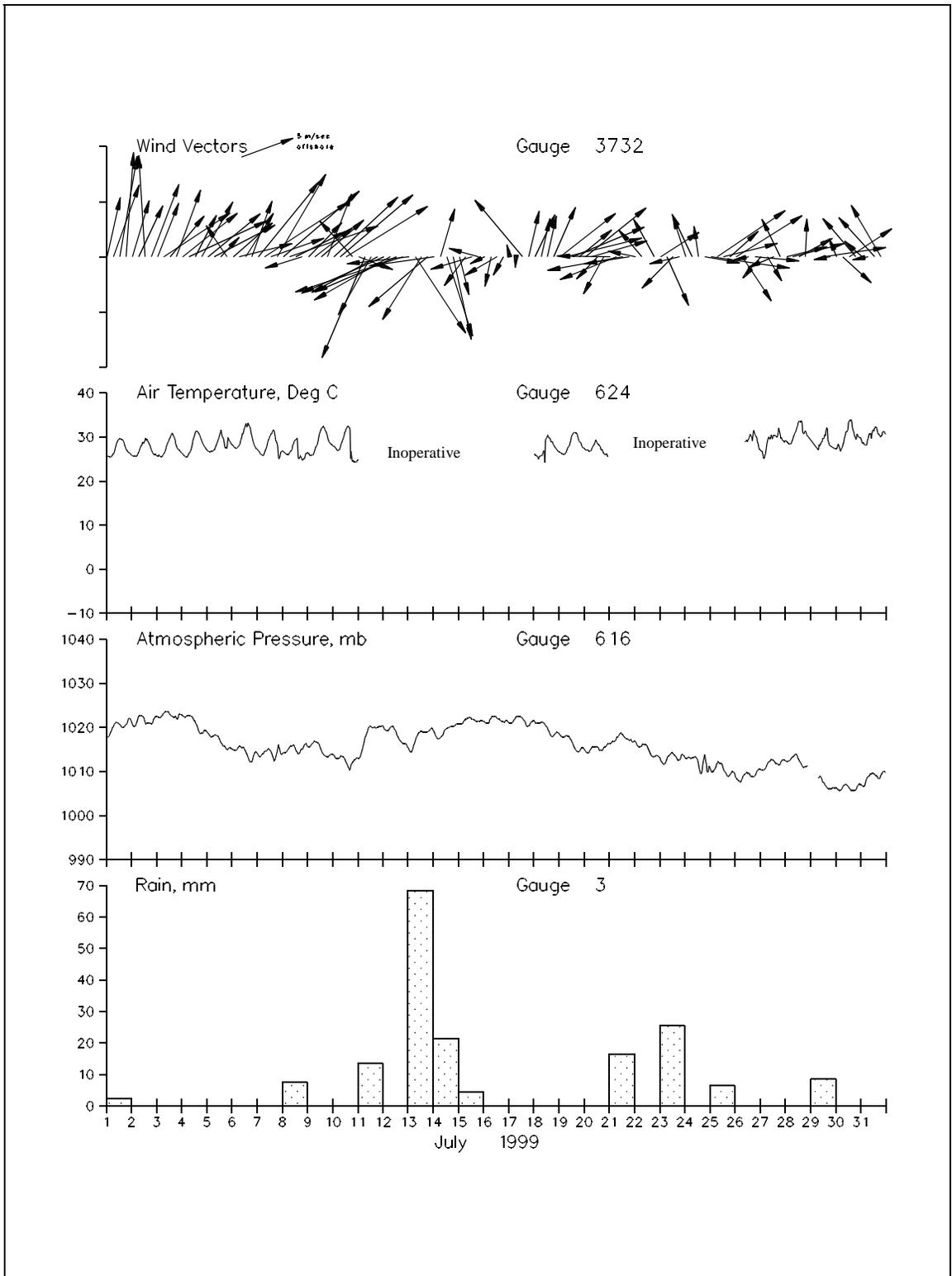


Figure 4. Meteorological Monthly Summary

**Table 3
Meteorological Data**

Jul 1999						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
1	100	5	200	30.6	1009.7	0
	700	7	199	26.3	1020.3	3
	1300	9	189	29.7	1020.7	0
	1900	10	183	27.3	1020.8	0
2	100	5	196	25.8	1020.7	0
	700	5	205	26.6	1022.6	0
	1300	9	176	29.3	1021.3	0
	1900	7	200	27.1	1020.9	0
3	100	5	201	25.7	1022.5	0
	700	7	236	26.2	1023.2	0
	1300	5	219	29.8	1023.1	0
	1900	6	199	28.0	1022.2	0
4	100	6	231	26.2	1022.8	0
	700	8	245	26.3	1022.8	0
	1300	4	206	31.1	1021.2	0
	1900	6	209	29.2	1018.7	0
5	100	6	230	26.9	1018.8	0
	700	6	242	27.3	1018.2	0
	1300	2	223	31.1	1016.8	0
	1900	3	146	27.4	1015.0	0
6	100	5	228	28.0	1015.0	0
	700	5	255	28.2	1015.8	0
	1300	5	212	32.8	1014.6	0
	1900	5	199	30.2	1012.2	0
7	100	9	218	27.0	1013.9	0
	700	9	236	26.4	1014.7	0
	1300	5	250	30.6	1014.7	0
	1900	9	210	28.5	1014.5	0
8	100	9	228	26.7	1014.3	0
	700	8	250	26.5	1015.6	8
	1300	5	242	29.4	1014.9	0
	1900	4	72	24.7	1015.1	0
9	100	4	224	26.4	1015.6	0
	700	4	232	27.0	1016.9	0
	1300	5	229	31.8	1015.0	0
	1900	6	200	30.2	1013.5	0
10	100	8	226	27.9	1013.9	0
	700	9	229	27.5	1013.3	0
	1300	9	238	31.9	1012.1	0
	1900	4	137	24.4	1012.2	0

**Table 3
Meteorological Data (continued)**

Jul 1999						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
11	100	3	291		1013.0	0
	700	10	23		1017.8	14
	1300	6	29		1020.2	0
	1900	7	61		1020.1	0
12	100	8	66		1019.8	0
	700	8	60		1020.0	0
	1300	8	66		1018.6	0
	1900	10	71		1016.5	0
13	100	6	83		1014.9	0
	700	8	327		1017.2	69
	1300	7	32		1019.2	0
	1900	7	49		1019.2	0
14	100	6	82		1019.0	0
	700	5	196		1017.8	21
	1300	8	342		1019.9	0
	1900	8	347	inoperative	1020.2	0
15	100	4	346		1020.9	0
	700	3	36		1021.9	4
	1300	4	73		1022.0	0
	1900	3	106		1021.5	0
16	100	1	64		1021.3	0
	700	3	11		1022.2	0
	1300	3	60		1022.1	0
	1900	2	29		1021.4	0
17	100	1	167		1021.1	0
	700	1	3		1022.5	0
	1300	7	140		1022.2	0
	1900	4	192		1020.4	0
18	100	4	205	26.0	1021.4	0
	700	4	192	25.7	1021.3	0
	1300	4	192	30.3	1020.0	0
	1900	5	203	28.3	1018.3	0
19	100	6	231	26.6	1018.4	0
	700	7	256	26.6	1018.3	0
	1300	7	247	30.6	1016.5	0
	1900	4	230	29.1	1014.6	0
20	100	7	230	27.2	1014.8	0
	700	5	253	27.2	1015.4	0
	1300	3	43	28.3	1015.6	0
	1900	4	29	26.2	1015.6	0

**Table 3
Meteorological Data (concluded)**

Jul 1999						
Day	Hour	Wind Speed m/sec	Wind Direction deg TN	Temperature deg C	Atm Pressure mb	Precipitation mm
21	100	5	90		1016.5	0
	700	6	67		1017.8	17
	1300	7	80		1018.4	0
	1900	4	81		1017.2	0
22	100	3	101		1016.8	0
	700	3	139		1015.8	0
	1300	4	118		1016.0	0
23	1900	4	151		1013.5	0
	100	4	237	inoperative	1012.6	0
	700	5	335		1012.8	25
	1300	4	72		1014.1	0
24	1900	3	76		1012.7	0
	100	4	162		1013.1	0
	700	4	154		1013.2	0
	1300	3	171		1011.9	0
25	1900	3	279		1013.9	0
	100	7	278		1010.2	0
	700	7	235		1012.0	7
	1300	5	256		1010.6	0
26	1900	3	227		1009.3	0
	100	7	237		1008.7	0
	700	5	326		1008.5	0
	1300	1	78	29.6	1009.7	0
27	1900	4	275	30.6	1009.1	0
	100	3	41	26.9	1010.4	0
	700	3	329	29.3	1011.9	0
	1300	3	67	30.5	1012.5	0
	1900	4	154	30.5	1011.8	0
28	100	4	256	29.1	1012.4	0
	700	5	255	29.4	1013.4	0
	1300	3	240	33.6	1012.7	0
	1900	3	182	31.4	1011.2	0
29	100			inoperative		0
	700	5	238	27.0	1008.4	9
	1300	6	261	29.9	1007.5	0
	1900	2	80	27.9	1006.2	0
30	100	2	156	27.4	1006.3	0
	700	3	312	28.3	1006.6	0
	1300	5	236	33.7	1006.3	0
	1900	5	139	29.7	1005.9	0
31	100	2	132	28.9	1006.9	0
	700	1	79	29.7	1008.9	0
	1300	5	137	32.0	1009.4	0
	1900	5	150	30.0	1009.2	0
		Resultant		Mean	Mean	Total
		2	209	28.5	1015.9	177

3 Wave Data

Wave data are collected from three different sets of instruments, as shown in Table 1 and Figure 3. The first is an array of fifteen pressure gauges, collectively referred to as gauge 3111 (gauge 111 being one of them). Directional information is computed from these gauges using an iterative maximum likelihood estimator. The second is a Baylor staff gauge (625) and a pressure gauge (641), both attached to the pier. The third is a Waverider buoy (630). The data are collected, analyzed, and stored on optical disc using a Digital Equipment Corporation VAXstation 4000. Data is sampled at 2 Hertz, with five contiguous 34 minute records, for a total collection period of nearly 2 hours and 51 minutes. This report reflects the data collection periods of 0100, 0700, 1300, and 1900 EST. The results are based only on the first 34 minute record. The exception is the 8 Meter Array (3111) which condenses the first four records into one statistical value.

Wave height H_{mo} is an energy-based statistic equal to four times the standard deviation of the sea surface elevations. Wave height reported from the pressure gauge has been compensated for hydrodynamic attenuation using linear wave theory. Wave period is identified from the computation of a variance (energy) spectrum with 60 degrees of freedom calculated from a 34-min record. Peak wave period T_p is defined as the period associated with the maximum energy in the spectrum.

Table 4 presents the wave heights and periods for each wave record obtained at 6 hr intervals during the month. The monthly means and standard deviations from the means shown in Table 4 are average values computed from this data. Figure 5 is a time history of all H_{mo} and T_p values obtained for all gauges.

Differences in wave periods between wave gauges (Table 4 and Figure 5) may be the result of wave breaking, wave reformation, the presence of multiple wave trains containing nearly equal energy, and statistical variations in spectral estimations.

**Table 4
Wave Data**

Jul 1999										
Day	Hour	641 Pressure Gauge		625 Baylor Gauge		3111 8 Meter Array			630 Waverider	
		Hmo,m	Tp,sec	Hmo,m	Tp,sec	Hmo,m	Tp,sec	Dir,TN	Hmo,m	Tp,sec
1	0100	0.21	3.8	0.40	9.2	0.54	7.6	90	0.78	7.2
	0700	0.30	8.3	0.50	8.1	0.55	7.1	92	0.74	7.7
	1300	0.32	3.6	0.62	7.8	0.60	7.6	90	0.96	7.7
	1900	0.38	6.5	0.58	6.5	0.60	7.1	90	0.90	6.7
2	0100	0.20	6.5	0.45	6.5	0.41	6.2	90	0.62	6.3
	0700	0.22	6.1	0.45	5.9	0.45	5.3	122	0.53	8.4
	1300	0.27	3.5	0.53	8.1	0.50	5.9	94	0.69	5.9
	1900	0.33	4.5	0.55	7.8	0.54	6.6	92	0.86	6.3
3	0100	0.23	3.9	0.45	8.9	0.41	7.1	88	0.70	7.2
	0700	0.15	12.9	0.38	5.9	0.38	5.9	94	0.55	6.7
	1300	0.16	13.5	0.39	7.8	0.37	8.2	88	0.49	7.2
	1900	0.25	3.8	0.49	7.8	0.49	7.1	90	0.71	7.2
4	0100	0.23	8.6	0.43	8.6	0.46	8.2	88	0.64	7.7
	0700	0.16	8.3	0.42	8.3	0.46	8.2	86	0.61	8.4
	1300	0.21	8.3	0.39	8.3	0.49	8.2	88	0.59	8.4
	1900	0.26	3.8	0.51	8.1	0.50	8.2	86	0.69	8.4
5	0100	0.23	8.6	0.42	8.9	0.47	8.2	86	0.67	8.4
	0700	0.18	10.3	0.45	8.6	0.51	8.9	88	0.66	8.4
	1300	0.27	10.3	0.51	10.3	0.53	9.8	78	0.68	10.1
	1900	0.20	9.2	0.46	8.9	0.50	9.8	226	0.62	9.1
6	0100	0.25	8.9	0.44	9.5	0.45	9.8	226	0.62	9.1
	0700	0.16	8.9	0.41	9.5	0.42	8.9	88	0.52	9.1
	1300	0.23	9.9	0.43	9.2	0.42	8.9	222	0.58	10.1
	1900	0.21	9.9	0.46	9.2	0.41	9.8	78	0.55	9.1
7	0100	0.22	8.9	0.38	9.2	0.39	8.9	84	0.66	9.1
	0700	0.12	9.2	0.30	8.6	0.31	8.9	84	0.61	9.1
	1300	0.21	9.2	0.38	9.2	0.41	9.8	76	0.52	10.1
	1900	0.28	4.6	0.48	8.9	0.41	8.9	86	0.82	5.1
8	0100	0.22	9.2	0.31	9.2	0.32	8.9	84	0.63	6.3
	0700	0.14	4.2	0.30	9.2	0.29	8.9	88	0.52	9.1
	1300	0.23	5.3	0.35	5.5	0.34	8.9	228	0.52	5.9
	1900	0.18	14.3	0.30	8.9	0.29	8.9	88	0.39	9.1
9	0100	0.17	14.3	0.27	9.2	0.29	8.9	80	0.41	9.1
	0700	0.15	16.0	0.29	8.6	0.29	8.9	90	0.40	5.3
	1300	0.18	15.1	0.29	8.6	0.28	8.2	92	0.39	15.4
	1900	0.18	16.0	0.26	16.0	0.26	15.7	344	0.47	16.7
10	0100	0.15	16.0	0.25	15.1	0.27	15.7	76	0.51	15.4
	0700	0.16	16.0	0.26	16.0	0.25	15.7	332	0.46	15.4
	1300	0.16	15.1	0.24	15.1	0.27	15.7	330	0.40	15.4
	1900	0.24	16.0	0.38	3.4	0.29	15.7	342	0.69	3.9

Table 4
Wave Data (continued)

Jul 1999										
Day	Hour	641		625		3111			630	
		Pressure Hmo,m	Gauge Tp,sec	Baylor Hmo,m	Gauge Tp,sec	8 Meter Array Hmo,m Tp,sec		Dir,TN	Waverider Hmo,m	Tp,sec
11	0100	0.15	15.1	0.28	15.1	0.27	15.7	76	0.37	14.3
	0700	1.21	5.4	1.39	5.4	1.48	5.9	68	1.58	5.3
	1300	0.95	6.3	1.26	6.1	1.10	6.2	74	1.58	6.3
	1900	0.92	6.8	0.95	6.6	0.90	7.1	74	1.16	6.7
12	0100	0.68	6.8	1.05	6.8	1.01	6.6	74	1.36	6.3
	0700	0.84	5.6	1.14	5.5	1.11	5.6	78	1.42	5.6
	1300	0.90	6.0	1.46	6.0	1.61	6.6	80	1.76	6.3
	1900	1.22	7.0	1.89	6.5	1.96	7.6	82	2.26	7.2
13	0100	0.87	7.8	1.62	7.6	1.59	7.6	82	1.83	7.2
	0700	1.02	7.4	1.45	8.1	1.55	7.6	82	1.62	7.7
	1300	0.97	7.0	1.44	7.4	1.50	7.1	76	1.85	7.2
	1900	1.13	7.6	1.39	7.8	1.28	7.6	78	1.73	8.4
14	0100	0.84	8.3	1.26	8.3	1.24	8.2	80	1.50	7.7
	0700	0.87	8.3	1.07	8.6	1.03	8.2	82	1.39	7.7
	1300	0.79	5.7	1.00	7.4	1.01	8.2	84	1.18	8.4
	1900	1.19	7.2	1.25	7.2	1.25	6.6	80	1.47	6.7
15	0100	0.81	7.2	1.05	7.4	1.03	7.6	80	1.35	7.7
	0700	0.67	6.8	0.89	6.8	0.89	7.1	80	1.15	6.7
	1300	0.42	5.5	0.66	6.3	0.62	6.6	82	0.82	6.3
	1900	0.35	4.9	0.55	6.6	0.52	6.2	82	0.67	6.3
16	0100	0.25	6.6	0.42	6.3	0.42	6.6	78	0.51	6.7
	0700	0.27	5.6	0.50	5.7	0.56	6.2	82	0.61	5.9
	1300	0.28	6.8	0.48	6.8	0.47	6.6	80	0.64	6.7
	1900	0.23	4.6	0.40	7.4	0.38	6.6	82	0.54	6.3
17	0100	0.18	6.6	0.34	6.8	0.33	7.6	84	0.47	7.2
	0700	0.16	5.1	0.36	6.3	0.34	7.6	86	0.45	7.7
	1300	0.18	3.9	0.32	7.6	0.31	7.1	88	0.43	7.2
	1900	0.19	5.6	0.35	7.2	0.30	6.6	86	0.50	6.3
18	0100	0.15	14.3	0.25	7.8	0.29	7.1	86	0.37	7.2
	0700	0.14	14.3	0.29	14.3	0.31	7.1	88	0.37	6.7
	1300	0.18	13.5	0.33	6.6	0.31	13.6	216	0.44	14.3
	1900	0.14	13.5	0.29	9.2	0.26	13.6	250	0.40	13.4
19	0100	0.13	14.3	0.23	13.5	0.24	13.6	76	0.33	7.7
	0700	0.10	13.5	0.23	13.5	0.25	13.6	222	0.35	13.4
	1300	0.13	13.5	0.22	13.5	0.24	13.6	204	0.35	13.4
	1900	0.12	13.5	0.24	13.5	0.23	13.6	114	0.31	13.4
20	0100	0.11	13.5	0.18	13.5	0.20	13.6	62	0.33	13.4
	0700	0.10	13.5	0.21	12.9	0.21	13.6	212	0.28	13.4
	1300	0.16	12.9	0.27	12.9	0.27	8.2	86	0.34	13.4
	1900	0.12	12.9	0.23	12.9	0.22	13.6	206	0.33	12.6

Table 4
Wave Data (concluded)

Jul 1999										
Day	Hour	641		625		3111			630	
		Pressure Hmo,m	Gauge Tp,sec	Baylor Hmo,m	Gauge Tp,sec	8 Meter Array			Waverider Hmo,m	Tp,sec
						Hmo,m	Tp,sec	Dir,TN		
21	0100	0.29	3.6	0.44	3.6	0.32	3.9	30	0.52	3.6
	0700	0.32	4.5	0.54	4.5	0.44	4.2	66	0.58	4.4
	1300	0.53	4.6	0.78	4.5	0.73	4.4	72	0.90	4.4
	1900	0.41	4.9	0.67	5.2	0.61	5.3	76	0.80	5.3
22	0100	0.34	4.8	0.60	5.4	0.59	5.0	76	0.78	5.1
	0700	0.24	4.8	0.62	7.8	0.57	8.2	86	0.70	7.2
	1300	0.26	4.3	0.55	7.3				0.64	4.8
	1900	0.17	7.2						0.53	7.2
23	0100	0.18	8.9						0.50	7.2
	0700	0.14	11.7						0.44	8.4
	1300	0.20	12.2						0.45	7.7
	1900	0.17	12.9						0.40	8.4
24	0100	0.22	6.3						0.53	6.3
	0700	0.20	5.1						0.49	5.6
	1300	0.17	4.9						0.46	5.9
	1900	0.16	16.0						0.54	10.6
25	0100	0.11	16.0	inoperative		inoperative			0.44	11.2
	0700	0.13	16.0						0.41	11.8
	1300	0.13	15.1						0.32	15.4
	1900	0.15	11.2						0.30	11.2
26	0100	0.12	16.0						0.35	11.2
	0700	0.14	11.2						0.33	11.2
	1300	0.19	16.0						0.37	11.2
	1900	0.19	11.2						0.42	10.6
27	0100	0.14	11.2						0.34	10.1
	0700	0.17	11.2						0.37	10.1
	1300	0.15	14.3	0.36	9.9				0.38	10.1
	1900	0.19	10.3	0.36	9.9				0.39	10.1
28	0100	0.14	14.3	0.35	10.3				0.39	10.6
	0700	0.17	9.5	0.35	9.9				0.40	10.1
	1300	0.16	14.3	0.40	10.3				0.38	10.1
	1900	0.19	9.9	0.36	9.9				0.35	10.1
29	0100	inoperative				inoperative			0.38	9.1
	0700	0.19	9.5	0.37	9.5				0.48	10.6
	1300	0.14	9.9	0.40	11.2				0.41	10.1
	1900	0.24	4.6	0.44	9.9				0.47	10.1
30	0100	0.17	14.3	0.41	9.5				0.37	10.1
	0700	0.17	9.5	0.38	9.9				0.38	10.6
	1300	0.15	10.7	0.39	10.7				0.36	10.1
	1900	0.21	9.9	0.42	9.9				0.41	10.1
31	0100	0.17	12.9	0.41	9.9				0.42	10.1
	0700	0.18	10.7	0.42	9.5				0.36	9.1
	1300	0.23	2.8	0.48	9.5				0.52	10.6
	1900	0.28	4.7	0.50	9.2				0.59	4.2
	Mean	0.30	9.3	0.54	8.8	0.57	8.7	110	0.65	8.8
	Std dev	0.27	4.0	0.35	2.7	0.39	3.0	67	0.39	2.8

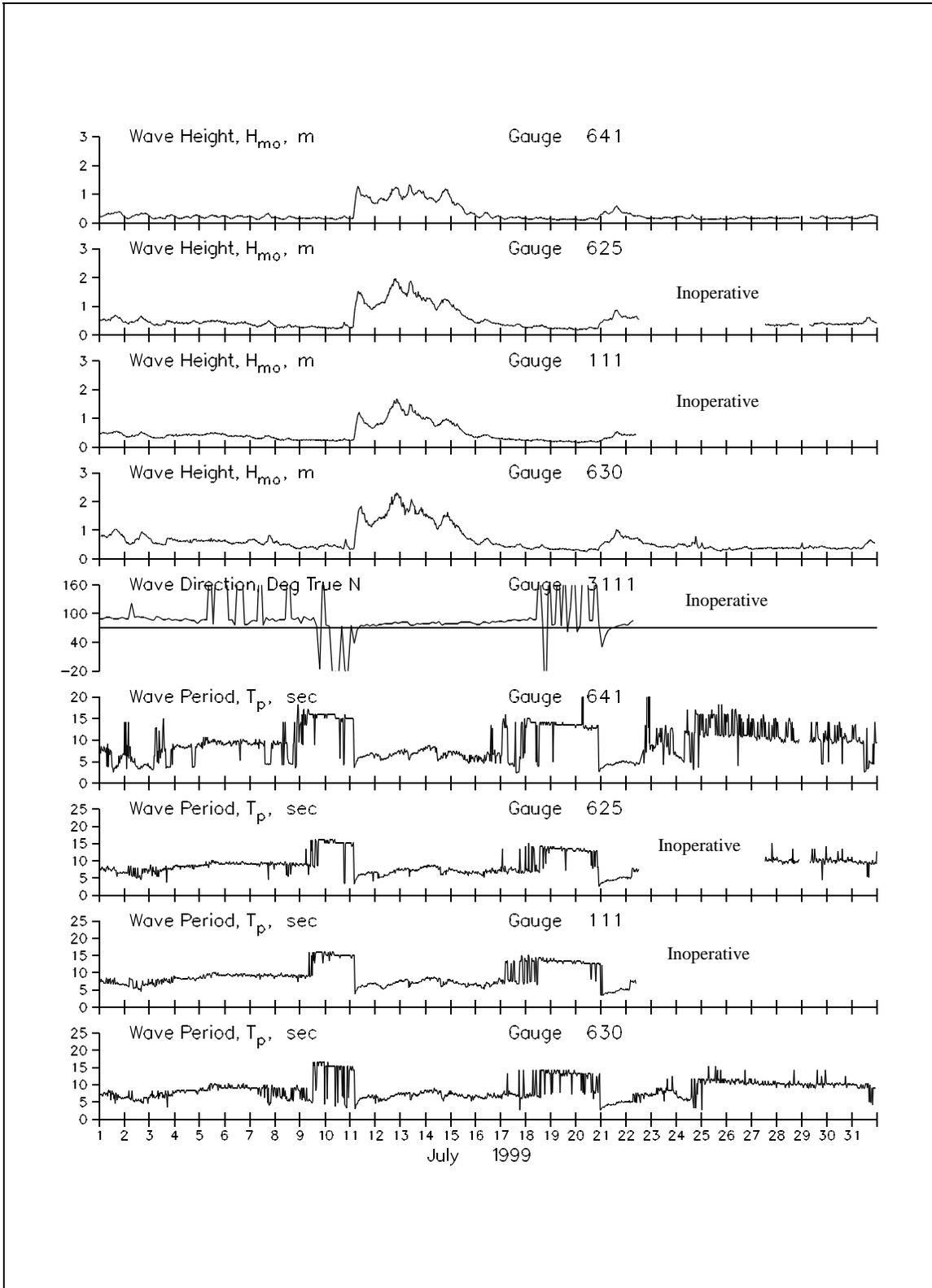


Figure 5. Wave Heights and Periods

4 Current Data

Current data (Table 5) are collected from a Sontek acoustic current meter and by visually observing the movement of small drogues on the water surface in the surf and at the seaward end of the pier, as well as 500 m updrift of the pier, approximately 12 m offshore (Table 6).

Since the shoreline orientation is approximately N20W, longshore currents flow either toward 340 deg (i.e. northward) or toward 160 deg (i.e. southward). Similarly, cross-shore currents are either onshore (westward) or offshore (eastward). All current speeds are given in centimeters per second (cm/sec). Resultant speeds and directions are determined by vector averaging the cross-shore and longshore data. Current directions indicate the direction that the current is moving towards. Current data are plotted in Figure 2.

**Table 5
Current Meter Data - Gauge 3539**

JULY 1999					
Day	Time	Cross Shore	Long Shore	Speed	Dir
1	100				
	700				
	1300				
	1900				
2	100	Data			
	700				
	1300	available			
	1900				
3	100	at a			
	700				
	1300	later			
	1900				
4	100	date			
	700				
	1300				
	1900				
5	100				
	700				
	1300				
	1900				
6	100				
	700				
	1300				
	1900				
7	100				
	700				
	1300				
	1900				
8	100				
	700				
	1300				
	1900				
9	100				
	700				
	1300				
	1900				
10	100				
	700				
	1300				
	1900				
11	100				
	700				
	1300				
	1900				
	1300				
	1900				
22	100				
	700				
	1300				
	1900				
23	100				
	700				
	1300				
	1900				
24	100				
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25	100				
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26	100				
	700				
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	1900				
27	100				
	700				
	1300				
	1900				
28	100				
	700				
	1300				
	1900				
29	100				
	700				
	1300				
	1900				
30	100				
	700				
	1300				
	1900				
31	100				
	700				
	1300				
	1900				
	1900				

KEY:
 +cross-shore = offshore, cm/sec
 -cross-shore = onshore, cm/sec
 +longshore = south, cm/sec
 -longshore = north, cm/sec
 Speed = Resultant speed, cm/sec
 Dir = Resultant direction, degrees true north

Table 6
Visually Observed Current Data

Jul 1999												
Day	Pier End				Mid-Surf Zone				Beach			
	Cross Shore	Long Shore	Speed	Dir	Cross Shore	Long Shore	Speed	Dir	Location	Speed	Dir	
1	51	-68	85	17	15	-38	41	2	South	72	N	
2	9	-30	32	357	18	-30	36	11	South	55	N	
3	27	-30	41	22	33	15	36	93	South	49	N	
4	19	-21	28	22	27	-30	41	22	South	49	N	
5	18	-20	27	22	20	-14	24	36	South	73	N	
6	15	20	25	123	8	20	22	138	South	2	N	
7	30	-15	34	43	14	-36	39	2	South	55	N	
8	30	20	37	104	13	-27	30	7	South	47	N	
9	17	-18	25	22	20	-27	33	17	South	79	N	
10	22	-29	36	17	23	-38	44	11	South	20	N	
11	-8	76	77	166	0	87	87	160	North	61	S	
12	-17	29	34	191	-8	25	27	177	North	14	S	
13	-15	102	103	169	-12	122	123	166	North	75	S	
14	14	15	21	118	12	13	18	118	North	12	S	
15	-14	34	36	182	-24	41	47	191	North	55	S	
16	6	20	21	143	6	16	17	138	North	26	S	
17	-13	-44	45	323	-8	-25	27	323	South	24	N	
18	9	-61	62	349	4	-25	26	349	South	49	N	
19	37	-41	55	22	0	10	10	160	South	61	S	
20	12	-41	42	357	12	-41	42	357	South	18	N	
21	-8	51	51	169	-3	23	23	169	North	24	S	
22	-5	30	31	169	23	17	28	107	North	14	N	
23	4	38	38	154	7	22	23	143	North	14	N	
24	20	-51	55	2	4	-36	36	346	South	18	N	
25	26	47	54	131	14	47	49	143	South	2	N	
26	0	18	18	160	7	34	35	149	North	0		
27	0	87	87	160	2	38	38	157	North	14	S	
28	18	30	36	129	22	12	25	99	North	0		
29	18	36	40	133	10	14	17	125	North	33	N	
30	8	25	27	143	3	18	19	151	North	18	S	
31	-16	29	33	189	-6	18	20	179	North	14	S	

KEY:
+cross-shore = offshore, cm/sec
-cross-shore = onshore, cm/sec
+longshore = south, cm/sec
-longshore = north, cm/sec
Speed = Resultant speed, cm/sec
Dir = Resultant direction, degrees true north

5 Visual Observations

Visual wave direction measurements (Table 7) of both the primary wave train (i.e. that having the higher wave heights) and the secondary wave train (which must be clearly distinguishable as a wave train separate from the primary waves but not surface chop or capillary waves) are taken daily at the seaward end of the pier. The pier axis (considered perpendicular to the beach at the FRF) is oriented 70 deg east of true north; consequently, wave angles greater than 70 deg indicate that the waves were coming from the south side of the pier.

The width of the surf zone (seawardmost breaker position to shoreline) is determined from the pier deck.

Measurements of surface water temperature, density, and depth of visibility are also taken daily at the seaward end of the pier. A Bucket Thermometer is lowered about 0.3 m into the water and allowed to remain for at least one minute. The temperature is then read, and a hydrometer is used to determine the density. A Secchi disc is used to determine the depth of visibility.

Table 7
Visual Observations

Jul 1999								
Day	Time	Wave Approach Angle at Pier End (degrees from True N)		Surf Zone Width, m	Water Characteristics at Pier End			
		Primary	Secondary		Temp., C	Density g/cc	Secchi Vis., m	
1	0713	40	25	56	17.8	1.0232	2.1	
2	0700	90	20	27	17.9	1.0233	2.7	
3	0932	45	130	37			2.7	
4	0936	110	10	53	22.1	1.0236	2.4	
5	0730	80	45	26	22.7	1.0232	2.7	
6	0710	100	80	56	22.4	1.0232	3.4	
7	0705	90	60	26	20.4	1.0232	2.4	
8	0715	70	75	16	20.3	1.0232	2.4	
9	0700	120	40	60	21.4	1.0228	2.7	
10	1308	90	50	12	20.0	1.0234	3.0	
11	1125	40	20	214	20.9	1.0228	1.5	
12	0530	60	70	71	21.9	1.0220	1.8	
13	0915	40	20	230	23.1	1.0197	0.6	
14	0722	50	30	91	23.2	1.0187	0.6	
15	0700	60	40	43	22.3	1.0194	0.9	
16	0730	40	5	62	22.5	1.0200	0.9	
17	0930	80	100	11	23.1	1.0200	1.8	
18	0930	125	20	9	21.9	1.0215	1.5	
19	0646	80	45	15	22.1	1.0223	1.5	
20	0810	80	80	10	22.8	1.0221	2.7	
21	0730	60	35	75	25.2	1.0197	3.7	
22	0649	60	45	63	25.5	1.0192	3.7	
23	0715	65	50	10	25.0	1.0250	3.7	
24	1208	55	30	17	24.6	1.0211	3.7	
25	0650	80	30	15	23.3	1.0162	2.4	
26	0716	70	0	20	24.1	1.0173	4.0	
27	0710	65	130	5	26.2	1.0195	4.9	
28	0625	90	95	16	26.3	1.0175	4.0	
29	0800	80	140	13	26.5	1.0198	4.3	
30	0720	90	30	20	27.1	1.0193	4.3	
31	0836	70	55	13	28.0	1.0180	5.5	

6 Water Levels

Since 1978, the National Oceanic and Atmospheric Administration (NOAA)/National Ocean Service (NOS) has operated a primary tide station (No. 865-1370) at the seaward end of the FRF pier. A NOS acoustic tide gauge (Next Generation Water Level Measurement System, NGWLMS) is used to collect water level data every 6 minutes throughout the month.

The variation in water level during the month is shown in Figure 6 along with a list of means and extreme values. This presentation is useful in identifying effects of both meteorological and astronomical forces on the open coast water level. Table 8 contains the range, high, low, and mean water level for each 12.42-hr tidal cycle.

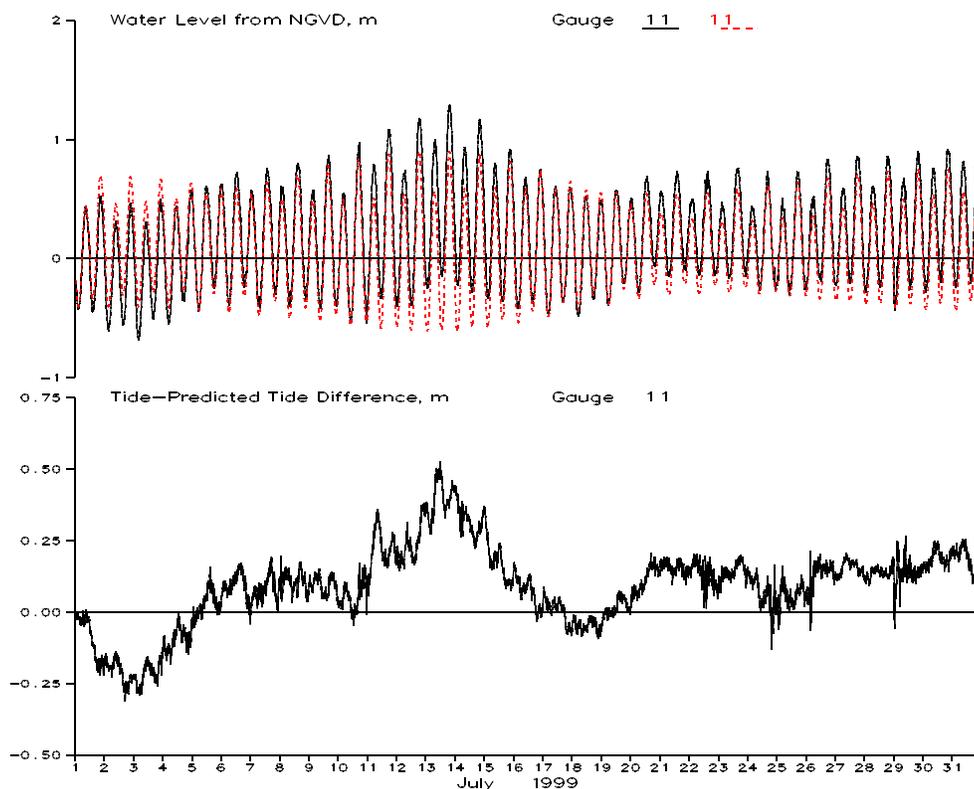


Figure 6. Water Level Variation

Table 8
Water Levels, m NGVD

JUL 1999 Tide Levels															
High			Low			Mean	Range	High			Low		Mean	Range	
Day	Time	m	Day	Time	m	m	m	Day	Time	m	Day	Time	m	m	m
1	0906	0.45	1	0248	-0.43	0.00	0.88	16	2200	0.75	16	1530	-0.38	0.18	1.13
1	2036	0.53	1	1436	-0.44	0.02	0.97	17	1024	0.61	17	0354	-0.47	0.08	1.08
2	0924	0.32	2	0330	-0.61	-0.15	0.93	17	2218	0.60	17	1648	-0.36	0.10	0.96
2	2142	0.47	2	1530	-0.56	-0.06	1.03	18	1130	0.52	18	0506	-0.49	0.03	1.02
3	1012	0.31	3	0418	-0.69	-0.18	1.00	18	2330	0.49	18	1748	-0.34	0.08	0.84
3	2212	0.50	3	1606	-0.51	-0.01	1.01	19	1218	0.57	19	0530	-0.40	0.11	0.97
4	1106	0.44	4	0500	-0.56	-0.05	1.00	20	0036	0.51	19	1842	-0.21	0.15	0.72
4	2324	0.57	4	1730	-0.36	0.09	0.94	20	1336	0.69	20	0700	-0.29	0.22	0.99
5	1148	0.61	5	0530	-0.45	0.10	1.05	21	0100	0.57	20	2030	-0.07	0.25	0.64
6	0030	0.63	5	1818	-0.25	0.19	0.88	21	1400	0.73	21	0736	-0.16	0.28	0.89
6	1300	0.72	6	0636	-0.39	0.19	1.12	22	0224	0.50	21	2118	-0.10	0.22	0.60
7	0100	0.57	6	1900	-0.24	0.17	0.82	22	1500	0.73	22	0812	-0.15	0.27	0.88
7	1348	0.76	7	0748	-0.42	0.18	1.18	23	0300	0.47	22	2036	-0.15	0.16	0.62
8	0048	0.60	7	2042	-0.31	0.17	0.91	23	1624	0.76	23	0848	-0.17	0.29	0.93
8	1530	0.80	8	0818	-0.41	0.22	1.21	24	0348	0.44	23	2248	-0.15	0.17	0.59
9	0324	0.57	8	2148	-0.34	0.14	0.92	24	1648	0.73	24	1018	-0.27	0.20	1.00
9	1606	0.87	9	0906	-0.42	0.22	1.29	25	0442	0.51	24	2318	-0.28	0.09	0.79
10	0442	0.55	9	2224	-0.40	0.08	0.95	25	1642	0.73	25	1000	-0.30	0.21	1.03
10	1724	0.97	10	1036	-0.54	0.18	1.52	26	0618	0.52	25	2336	-0.27	0.12	0.79
11	0512	0.80	10	2318	-0.54	0.17	1.34	26	1754	0.83	26	1206	-0.19	0.31	1.03
11	1748	1.09	11	1100	-0.34	0.37	1.43	27	0630	0.59	27	0042	-0.23	0.18	0.82
12	0648	0.74	12	0042	-0.40	0.19	1.14	27	1818	0.86	27	1206	-0.21	0.33	1.07
12	1830	1.18	12	1230	-0.40	0.40	1.58	28	0648	0.61	28	0106	-0.29	0.18	0.90
13	0736	1.00	13	0136	-0.25	0.36	1.25	28	1912	0.86	28	1312	-0.25	0.31	1.11
13	1948	1.29	13	1312	-0.15	0.56	1.44	29	0830	0.68	29	0054	-0.44	0.18	1.12
14	0806	0.94	14	0212	-0.23	0.36	1.16	29	1936	0.90	29	1342	-0.26	0.32	1.16
14	2000	1.17	14	1418	-0.28	0.44	1.46	30	0812	0.76	30	0154	-0.29	0.24	1.05
15	0848	0.80	15	0306	-0.34	0.23	1.14	30	2018	0.92	30	1406	-0.20	0.37	1.12
15	2054	0.92	15	1506	-0.37	0.28	1.28	31	0906	0.82	31	0300	-0.25	0.28	1.07
16	0948	0.69	16	0330	-0.42	0.13	1.11	31	2112	0.84	31	1518	-0.21	0.31	1.05

7 Bathymetry

A. Nearshore Profiles. In order to document profile response away from the pier, surveys of four profile lines extending 900 to 1,000 m from shore and located 489 and 581 m north and 517 and 608 m south of the FRF pier are conducted bi-weekly, after storms, and during more complete bathymetric surveys.

These profiles are obtained using a Trimble 4000 SSE GPS for positioning, in combination with the Coastal Research Amphibious Buggy (CRAB), a 10.7 m high, self-powered, mobile tripod on wheels.

Figure 7 shows the last survey in June and the survey(s) in July on profile line 188, located 517 m south of the pier.

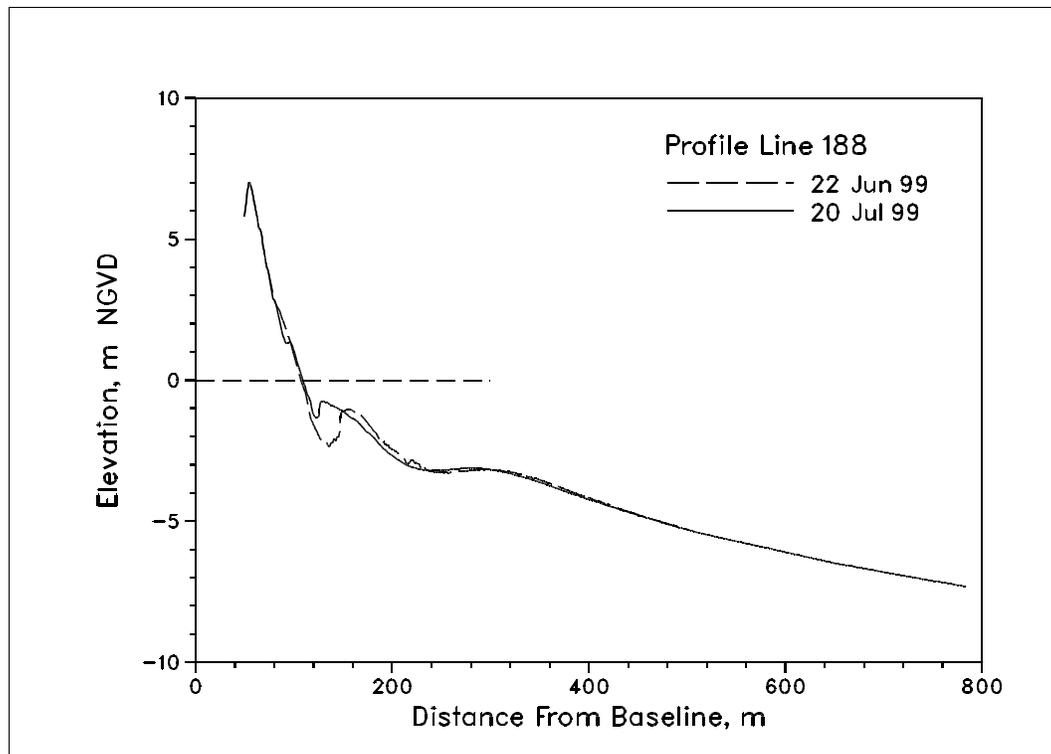


Figure 7. Monthly CRAB Profiles on Profile Line 188.

The profile envelope (Figure 8) reflects the maximum changes that occurred on the profile during 1999. Cross-hatched areas indicate changes to the annual envelope which occurred in July.

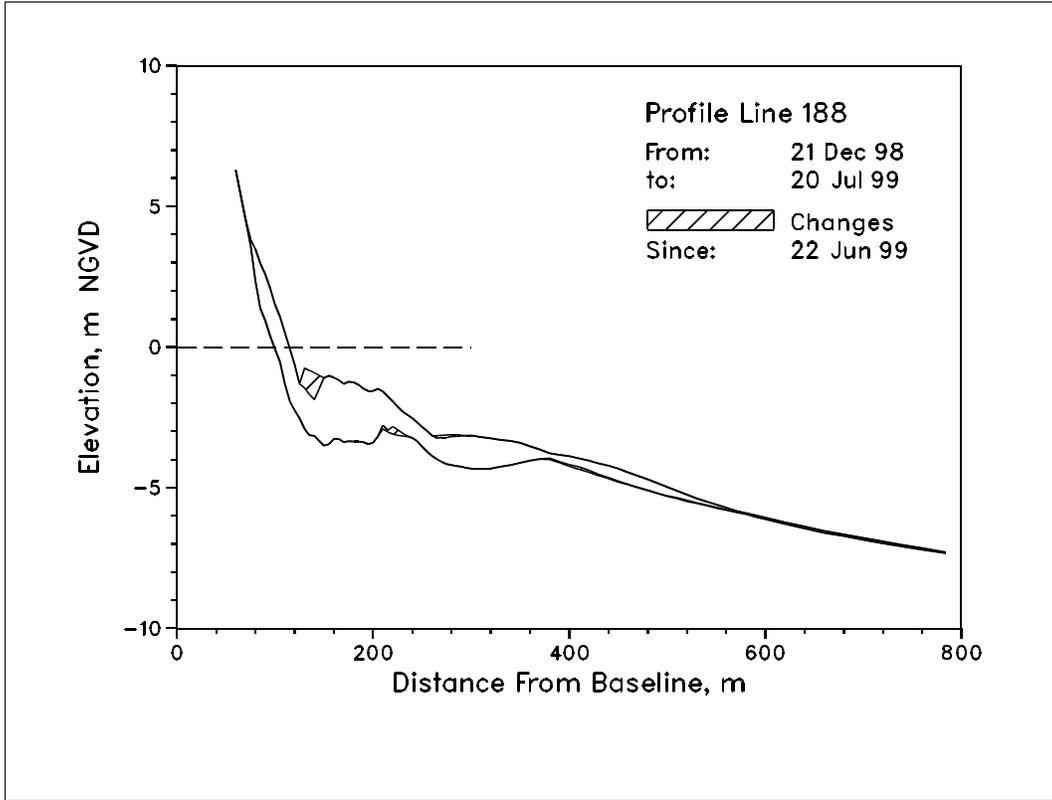


Figure 8. Profile Envelope - Profile Line 188.

B. Bathymetry. Figure 9 includes a two- and three-dimensional contour map and a change plot derived from the bathymetric survey on 19 July. Wide contour lines on the change diagram represent eroded areas; thin lines indicate deposition.

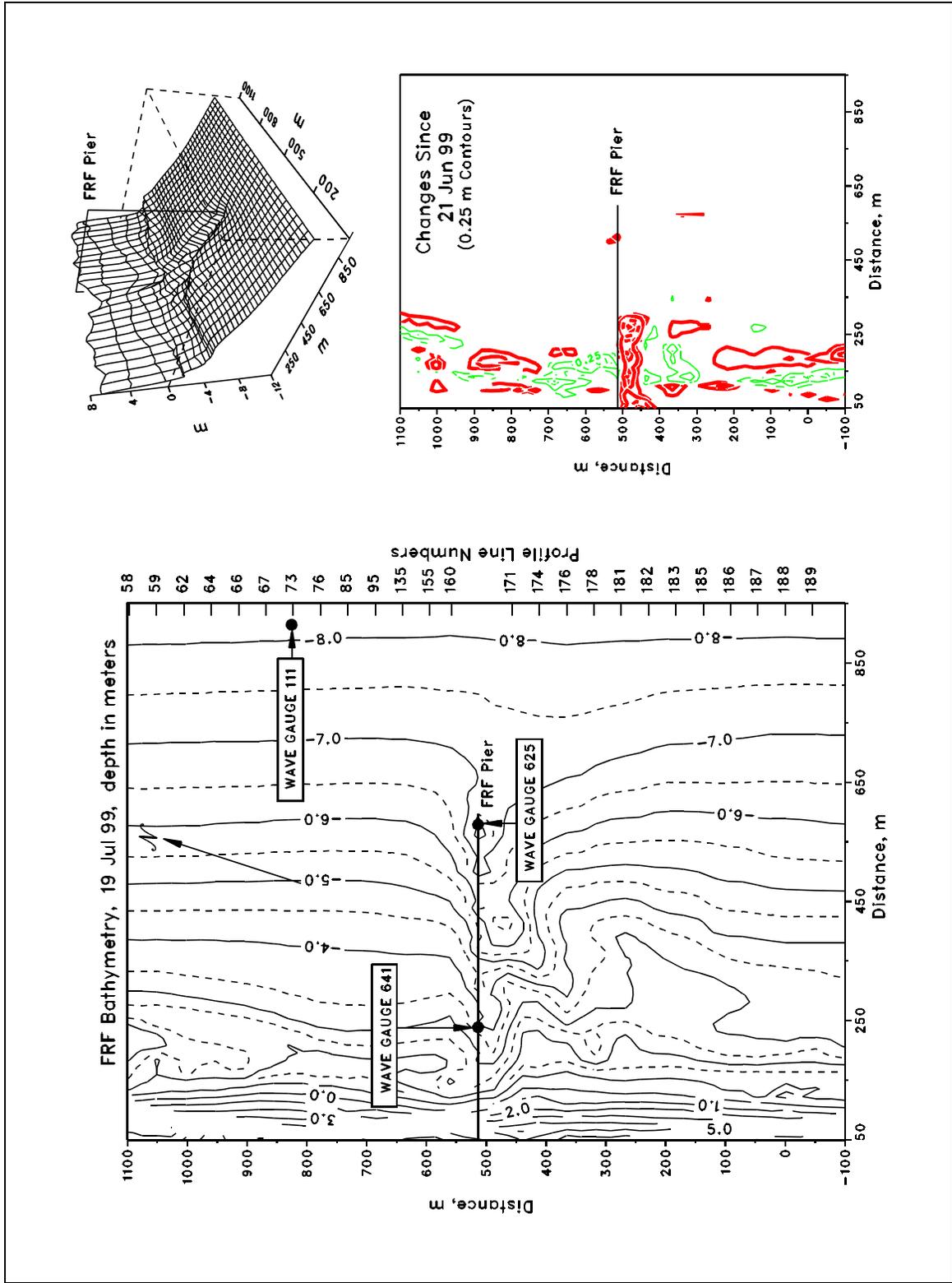


Figure 9. FRF Bathymetry, Depths Relative to NGVD